

CLAIMS

What is claimed is:

1. An apparatus for making nuclear magnetic resonance (NMR) measurements, comprising:
 - a. a magnet having a longitudinal axis, the magnet being twisted about the longitudinal axis to form a helical spatial configuration and to generate a helical static magnetic field substantially perpendicular to the longitudinal axis;
 - b. an antenna configured to generate a radio frequency (RF) magnetic field substantially perpendicular to the static magnetic field of the magnet and to receive NMR signals from excited nuclei; and
 - c. a protective collar overlaying at least a portion of the magnet and having a helical configuration substantially similar to the spatial configuration of the magnet.
2. The apparatus of claim 1, wherein the protective collar has one or more lateral projections extending outward from the collar and having substantially similar helical spatial configuration.
3. The apparatus of claim 1 further comprising drilling means.
4. The apparatus of claim 3, wherein the drilling means comprises a drill bit mounted on the protective collar.
5. The apparatus of claim 1, wherein the antenna is mounted in a recess of the protective collar.
6. The apparatus of claim 5, wherein the antenna is electrically isolated from the protective collar.
7. The apparatus of claim 1, wherein the protective collar is made of non-magnetic metal or metal alloy and the apparatus further comprises an electrically insulating and non-magnetic sleeve enclosing the collar and the antenna.
8. The apparatus of claim 7, wherein the sleeve comprises fiberglass.
9. The apparatus of claim 2, wherein the lateral projections comprise two lateral projections on opposite sides of the protective collar.
10. The apparatus of claim 9, wherein the protective collar has a twist angle that produces a 180° turn over the length of the magnet.

11. The apparatus of claim 5, wherein the antenna produces an approximation of a magnetic dipole field.
12. The apparatus of claim 5, wherein the antenna comprises two pairs of elongated conductors disposed along the length of the protective collar.
13. The apparatus of claim 5, wherein the antenna has a twisted saddle-shape.
14. The apparatus of claim 5, wherein the antenna comprises a combination of longitudinal and arc-shaped conductors.
15. The apparatus of claim 12, wherein each of said conductors is of a relatively narrow width defined by an arc of a first predetermined polar angle measured with respect to said axis, and wherein the distance between the centers of the arcs of each pair of conductors is a second predetermined polar angle measured with respect to said axis.
16. The apparatus of claim 15, wherein said first predetermined polar angle is approximately 15°.
17. The apparatus of claim 15, wherein said second predetermined polar angle is approximately 20°.
18. The apparatus of claim 12, wherein said pairs of electrical conductors are connected in series with each other, and wherein conductors of each pair are connected in parallel with each other.
19. The apparatus of claim 1, wherein the protective collar is made of non-magnetic metal alloy, including one or more of: Inconel 718, Monel metal and P-550 alloy.
20. The apparatus of claim 1, wherein said static magnetic field of the magnet is a gradient static magnetic field.
21. The apparatus of claim 1, wherein the magnet comprises a plurality of segments, successive segments being offset, so as to form an overall helical configuration over the length of the magnet.
22. The apparatus of claim 1, wherein the helical spatial configuration of the magnet comprises two or more sections, in which the angle or twist about the axis are different.
23. The apparatus of claim 1, wherein the angle of twist over the length of the magnet is 180°.
24. A method for manufacturing NMR measurement devices, comprising the steps of:

- a. providing a magnet having a longitudinal axis, the magnet being twisted about the longitudinal axis to form a helical spatial configuration and to generate a helical static magnetic field substantially perpendicular to the longitudinal axis;
 - b. installing a protective collar overlaying at least a portion of the magnet and having a helical configuration substantially similar to the spatial configuration of the magnet; and
 - c. mounting in a recess of the protective collar an antenna configured to generate a radio frequency (RF) magnetic field substantially perpendicular to the static magnetic field of the magnet and to receive NMR signals from excited nuclei.
25. The method of claim 24, wherein the step of installing a protective collar comprises installing one or more lateral projections extending outward from the collar and having substantially similar helical spatial configuration.
26. The method of claim 24 further comprising the step of installing drilling means comprising a drill bit mounted on the protective collar.
27. The method of claim 24, wherein step of mounting the antenna comprises the step of providing an electrical isolation from the protective collar.
28. The method of claim 24 further comprising the step of installing an electrically insulating and non-magnetic sleeve enclosing the collar and the antenna.
29. The method of claim 24, wherein the step of providing a magnet comprises providing a plurality of segments, successive segments being offset, so as to form an overall helical configuration over the length of the magnet.